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The Relation of Urine Specific Gravity to Its Composition and Osmolality in the Normal Korean*

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ABSTRACT

A random urine sample was obtained from each of 155 normal Koreans and its specific gravity (S.G.), the total osmolality (U_{osm}) and the concentration of chloride (U_{Cl}) and urea (U_{urea}) were determined. The U_{osm}, $2 \times U_{Cl}$ and U_{urea} were then plotted as a function of the S. G., and the following regression equations were obtaind: U_{osm} (in mOsm/kg)=34,500 (S. G.−1.000), $2 \times U_{Cl}$ (in mOsm/kg)=20,000 (S.G. 1.000), and U_{urea} (in mOsm/kg)=10,000 (S.G.−1.000). The analysis of these data indicated that 58.5% of the U_{osm} could be accounted for by NaCl and 28.8% by urea while 41.0% of the S. G. of urine could be accounted for by NaCl and only 14.5% by urea. A comparison of these data with corresponding figures obtained from occidentals suggests that, in the Korean, the contribution of NaCl to both the U_{osm} and S. G. of urine is considerably higher, while that of urea is significantly lower than that in the occidental. This peculiarity of the urinary composition in Koreans is attributed to their ingestion of a low-protein, high-salt diet.

Because of its simplicity, the specific gravity of urine is almost routinely determined in the clinical evaluation of certain renal function such as the ability to dilute or to concentrate urine under a given test condition. In so doing, it is conveniently assumed that the value of the urine specific gravity is a function of the urine osmolality. Although this assumption may be true to some extent, it is by no means warranted under certain conditions, such as in the case of proteinuria. It is also important to point out that the relationship between the specific gravity and the osmolality of urine is determined by the fractional composition of various solutes, especially of NaCl and urea, which contribute to different extents to the specific gravity and to the osmolality.

Since it is known that Korean people daily consume more NaCl (Lee, unpublished data) while on a low protein diet (Lee et al., 1962), it is likely that the urine composition is different from that in occidentals. In fact, it has been shown by Suh and Hong (1961) that, in the Korean, 2/3 of the urine osmolality is contributed by NaCl, while less than 1/3 is by urea. Similar findings were also reported by Yoon and Hong (1961). These facts are in contrast to those of the occidental in that urea and NaCl are normally responsible for approximately 40% and 30%, respectively, of the urine osmolality (McCance, 1945; Epstein et al., 1957).

In view of these peculiarities of urine composition in the Korean, attempts have been made to correlate the urine specific gravity of the Korean to the total osmolality as well as to the concentration of NaCl and urea. It was hoped that this correlation would help clinicians in evaluating certain renal functions by simply measuring the specific gravity of urine.

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METHOD

The subjects consisted of 155 Koreans, 107 males and 48 females, who came to the outpatient clinic of the University Hospital. Their age ranged from 3 years old to 67 (see Table 1), and special care was taken to eliminate those who had either cardiovascular or renal disease.

Table 1. Distribution of subjects by age and sex

Age (years)	No. of Subjects		
	Male	Female	Total
<10	10	5	15
11~20	28	14	42
21~30	31	15	46
31~40	21	5	26
41~50	10	6	16
51~60	4	2	6
>61	3	1	4
Total	107	48	155

Table 2. Distribution of specific gravity of urine by the number of subjects

Specific gravity	No. of Subjects
1.008 ~ 1.009	4
1.010 ~ 1.011	5
1.012 ~ 1.013	10
1.014 ~ 1.015	9
1.016 ~ 1.017	7
1.018 ~ 1.019	8
1.020 ~ 1.021	19
1.022 ~ 1.023	20
1.024 ~ 1.025	13
1.026 ~ 1.027	20
1.028 ~ 1.029	23
1.030 ~ 1.031	5
1.032 ~ 1.033	6
1.034 ~ 1.035	4
1.036 ~ 1.037	1
1.038	1
Total	155

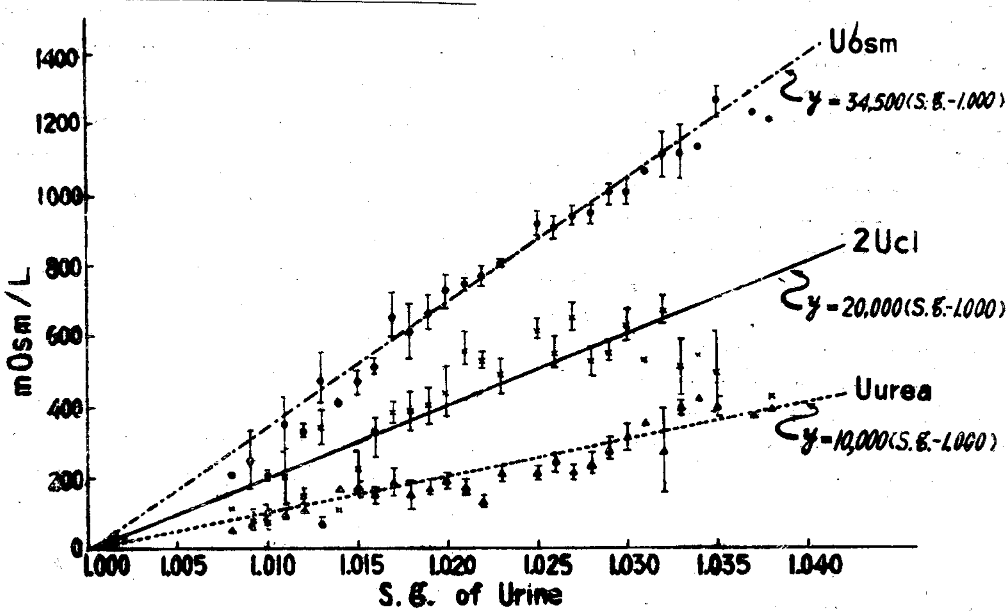

Fig. 1. The relationship between the urine specific gravity (S. G.) and the total osmolality (U_{osm}) or the osmolality contributed by either urea (U_{urea}) or NaCl ($2\times U_{Cl}$) (Mean±S. E.). Three straight lines were drawn by visual inspection and the equation for each line is indicated under the respective line.

A random urine sample was taken from each subject, and the specific gravity, the osmolality and the concentration of chloride and urea were determined. The specific gravity was measured by use of a urinometer at room temperature and was subsequently converted to that at 15°C on the basis of the "Smithonian Table" shown in the "Handbook of Physics and Chemistry." The value of the specific gravity was read accurately to 1/1,000. The osmolality was determined by the use of the Fiske osmometer, the chloride by the method of Schales and Schales (1941) as modified later by Asper et al. (1947). The urea was determined by the method of Van Slyke and Cullen (1916).

RESULT AND DISCUSSION

Inasmuch as the degree of hydration was not controlled in the present investigation, a wide variety of urine concentrations was obtained, as indicated by the values of the specific gravity, which ranged from 1.008 to 1.038 (Table 2). The osmolality of urine ranged from 187 to 1312 mOsm/Kg, while the concentrations of chloride and urea ranged from 20 to 430 mEq/L and from 20 to 482 mM/L, respectively. In general, these values were proportional to the specific gravity. In order to evaluate the quantitative relationship among these variables, the total osmolality as well as the osmolality contributed by NaCl (estimated by multiplying the chloride concentration by 2) and urea were plotted against the value of the specific gravity (Fig. 1). In computing the osmotic contribution of NaCl and urea, the osmotic coefficient was assumed to be 1.0. For a given specific gravity, the mean value and the standard error were computed and were used in constructing this graph. In case the number of samples with the same specific gravity were less than 2, the standard error was not computed and the mean value alone is indicated.

It is clear from Fig. 1 that, although there is a certain degree of deviation, there appears to be a fairly linear relationship between the osmolality due to either the total solute, NaCl or urea, and the specific gravity. Hence, the best-fitting straight line was drawn for each variable by visual inspection, and the equation for each line is indicated in the figure.

On the basis of these results, it can be said that the urine osmolality accounted for by NaCl is, on the average, 58.5%, while that by urea was 28.8%. Moreover, when the urine specific gravity accounted for by NaCl and urea was calculated by using the specific gravity increment of 0.00413 and 0.00162 for 100 mM/L of the respective solute, NaCl could account for, on the average, 41.0%, and urea for 14.5%, of the specific gravity. These figures may be compared with the data reported by various investigators as shown in Table 3. Comparable figures obtained on a small number of normal Koreans by Yoon and Hong (1961), Suh and Hong (1961) and also by Kim (unpublished data) agree very closely with the present investigation on a larger number of subjects. On the other hand, data obtained from both Americans and British who are maintained on either an ordinary diet or a high protein diet (Price et al., 1940; Miller et al., 1941; McCance, 1945) indicate that the contribution of NaCl to both osmolality and the specific gravity was considerably lower, while that of urea was higher than the respective value for the Korean. However, in those Americans who are deliberately maintained on a low protein diet (Price et al., 1940; Epstein et al., 1957), the contribution of urea to both the total osmolality and the

Table 3. Percent contribution of NaCl and urea to the specific gravity (S. G.) and the total osmolality (U_{osm}) of urine

Subjects	% of S.G. accounted for by		% of U_{osm} accounted for by	
	Urea	NaCl	Urea	NaCl
Koreans				
Hong, Park & Hong	14.5	41.0	28.8	58.5
Yoon & Hong (1961)	—	—	19.8	57.7
Suh & Hong (1961)	—	—	—	53.2
Kim (unpublished data)	18.3	48.5	28.2	58.8
Americans				
Price et al. (1940)				
low protein	20.0	29.2	—	—
high protein	28.0	26.8	—	—
Miller et al. (1941)				
ordinary diet	21.8	30.9	—	—
Epstein et al. (1957)				
low protein	—	—	25.0	—
high protein	—	—	40.0	—
British				
McCance (1945)				
ordinary diet	—	—	41.0	32.0
〃 〃 +salt	—	—	—	62.0

specific gravity was quite comparable to that in the Korean, while that of NaCl seems to be still lower than that in the Korean. This lower percent contribution of NaCl in the occidental became higher when 8 to 30 gm of salt were added to the regular diet (McCance, 1945).

It is thus evident from a consideration of the above findings that the peculiarities in the percent contribution of urea and NaCl to both the total urine osmolality and the specific gravity seem to be due to the ingestion of both a low-protein and a high-salt diet (Lee et al., 1962). This conclusion is also in compliance with the findings by Suh and Hong (1961) that the renal concentrating ability seems to be lowered in the Korean, which was also attributed by them to the ingestion of a low-protein diet. It has been reported earlier by Epstein et al. (1957) that the amount of protein intake is important in determining the extent of the renal concentrating operation.

Regardless of what may be responsible for this unique composition of urine excreted by the Korean, the results of the present investigation are of paramount importance in estimating the urinary osmolality, as well as the urinary concentration of NaCl or urea, by simply measuring the specific gravity of urine alone. As is evident from the above discussion, one cannot estimate these values in the Korean on the basis of comparable data obtained from the occidental.

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